Notice of Allowability	Application No. 10/063,423	Applicant(s) DRAYER, THOMAS HUDSON	
	Examiner Yubin Hung	Art Unit 2625	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--
All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *application filed on 22 April 2002*.
2. ☒ The allowed claim(s) is/are *1-13*.
3. ☒ The drawings filed on *22 April 2002* are accepted by the Examiner.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. ______ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: ______.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date ______.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date ______.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)
1. ☒ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO-1449 or PTO/SB/08), Paper No./Mail Date ______
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application (PTO-152)
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date ______ .
7. ☒ Examiner's Amendment/Comment
8. ☒ Examiner's Statement of Reasons for Allowance
9. ☐ Other ______.

EXAMINER'S AMENDMENT

1. An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in telephone interviews with Mr. Robert Morelli on April 14 and 15, 2005

2. The application has been amended according to **Appendix A**.

Allowable Subject Matter

3. Claims 1-13 as amended by the examiner are allowed.

4. The following is an examiner's statement of reasons for allowance:

Regarding claim 1, closest art of record discloses binarizing an up-sampled image (Seeger et al., US 6,577,762: Col. 9, lines 7-16); classifying by a mixture of Gaussians that approximates a distribution (Vaisberg et al., US 6,876,760: Col. 17, line 60-Col. 18, line 17); using histogram modeling to classify pixels into two categories

(Taxt et al., "Segmentation of Document Images," *IEEE Transaction on Pattern Analysis and Machine Intelligence*, Vol. 11, No. 12, December 1989, pp. 1322-1329; and using histogram modeling to select thresholds (Sahoo et al., "Threshold Selection Based on Histogram Modeling," *IEEE International Conference on Systems, Man and Cybernetics*, Vol. 1, 18-21 October 1992, pp. 351-356). However, none of the above references disclose, teach or suggest that the modeling is done with respect to the original input image using a number (N) of functions (say, F_i, i =1...N) such that N depends on the scale of the up-sampling and that the index of the function that yields the maximal value for a given pixel determines the number of foreground pixels of the area in the up-sampled image that corresponds to the pixel.

5. Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Contact Information

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Yubin Hung whose telephone number is (571) 272-7451. The examiner can normally be reached on 7:30 - 4:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Bhavesh Mehta can be reached on (571) 272-7453. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

BHAVESH M. MEHTA
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 2600

Yubin Hung
Patent Examiner
April 15, 2005

APPENDIX A

7. Lines 4 and 9 of page 12, the equation at the top of page 13 and lines 5-6 of page 16 have been amended as indicated (in red ink) on the following three pages.

output image can have 0, 1, 2, 3, or 4 foreground (or alternatively background) pixels.

[0050] Each of the individual functions defined above should model the contribution to the original histogram *H(z)* of input gray scale image pixel intensities for one of the (p x q + 1) possibilities, each representing the ratio of foreground to total ~~background~~ area of the corresponding spatial pixel area scanned into the pixel value. As an exemplar where *p* and *q* both take the value 2, there will be at least five individual functions to model the distribution of gray scale pixel values in the input image that create 0, 1, 2, 3, or 4 foreground pixels in the high resolution binary output image, representing ratios of 0:4, 1:4, 2:4, 3:4 and 4:4 ~~4:4, 3:4, 2:4, 1:4, and 0:4~~ foreground to total area. There may be additional models, if multiple models are used for the distribution of one of the (p x q + 1) possibilities, so the number of models is defined to be $K_{Mod} > (p \times q)$.

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[0051] In the preferred embodiment each of the individual functions are defined as Gaussian in accordance with the following:

$$f(z,\phi_i) = e^{(z-\mu_i)^2 / \sigma_i^2}$$

In this equation, individual functions are not indexed because they have the same form, and the function parameters, ϕ_i, are the mean, μ_i, and variance, σ_i, of each Gaussian function.

[0052]

Modeling of the histogram involves searching for or calculating the number of models, the parameters for all the individual functions, and the scale factors that minimize the modeling error, the difference between *H(z)* and $H_M(z)$. This modeling error can be computed in a number of ways. In the preferred embodiment, the modeling error is computed as the sum of absolute differences between the two histograms, defined as follows:

J.H.

$$D(H,H_M) = \sum_{z=z_{min}}^{z_{max}} abs[H(z) - H_M(z)]$$

In the above equation, the function *abs[j]* returns the absolute value of the input variable *j*. There are many possible techniques for searching for function parameters that minimize the modeling error, further, it is not required to find the exact parameters that minimize the modeling error. In the preferred embodiment, approximate solutions are used. A search is performed on the space of function parameters and scale factors and set of parameters and scale factors that minimize the modeling error from the limited set of values searched is used.

[0053] Next, step 140, the input gray scale pixel values (from step 110) are classified into one of (p x q + 1) classes, one class for each of the possibilities for the number of output foreground pixels as determined in step 130. In the preferred embodiment, for an input gray scale pixel value $z = I(x,y)$, the model with the highest value at intensity value z, MAX$\{ \alpha_i f_i(z, \phi_i); 0 < i <= K_{Mod} \}$, determines the classification of the pixel, and therefore the number of foreground pixels, *m(x,y)*, in the corresponding *p x q* region of the output binary image.

[0054]

Next, step 160, performs quantization of the high resolution gray scale image to produce a high resolution binary image, the output of the image binarization using the histogram modeling process. In a prior step 140, the number of foreground pixels *m(x,y)* in each *p* x *q* region of the output image was determined by classifying input gray scale image pixels. This step, 160, uses the high resolution gray scale image to determine how to distribute the *m* foreground pixels among the pixels in the corresponding *p* x *q* array of the output binary image. This is trivial when *m(x,y)* is equal to 0 or *p x q*. In these cases, all pixels are either foreground or background. Other cases are determined by the pixel values in the high resolution gray scale image. In the preferred embodiment, each *p* x *q* region in the high resolution gray scale image is examined, the *m(x,y)* "darkest" pixels are identified, and their corresponding locations in the binary output image are set to the foreground value.

Claims

[c1] 1. A method of image binarization using histogram modeling, comprising the steps of:

from a source having foreground and background luminance areas, obtaining a gray scale digital input image comprising a plurality of pixels having respective gray scale values corresponding to the average intensity of the source ~~gray scale digital input image~~ over a particular pixel location;

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creating a higher spatial resolution gray scale image comprising a plurality of *p x q* arrays of pixels, one of each of said *p x q* arrays for each of the pixels in said gray scale digital input image, with the gray scale values of each of said pixels in each of said *p x q* arrays of pixels calculated from the gray scale values of the pixels of said gray scale digital input image;

creating a higher spatial resolution binary image comprising a plurality of *p x q* arrays of pixels, one of each of said *p x q* arrays for each of the pixels in said gray scale digital input image, with each pixel in each of said *p x q* arrays in said higher spatial resolution binary image having a binary value representing foreground or background;

creating (p x q + 1) classes of number m, where m is the possible numbers of pixels in each of said *p x q* array of pixels in said higher spatial resolution binary image having a binary value representing foreground;

creating a histogram of the number of each gray scale value for the plurality of pixels in said gray scale digital input image;

modeling said histogram with (p x q + 1) functions, labeled function m, such that said function m of each of said functions models the portion of said histogram contributed by pixels from said gray scale digital input image having gray scale values proportional to the ratio of the source foreground luminance area to the source foreground luminance area plus the source background luminance area, in the corresponding particular pixel location, of m / (p x q);

assigning each of said plurality of gray scale digital input image pixel values to one of said classes, such that the said gray scale digital input image pixel value is most likely to belong to the portion of said histogram modeled by the corresponding function; and

for each of said *p x q* array of pixels in said higher spatial resolution binary